

DCC BRDF netCDF formats and pixel resolution

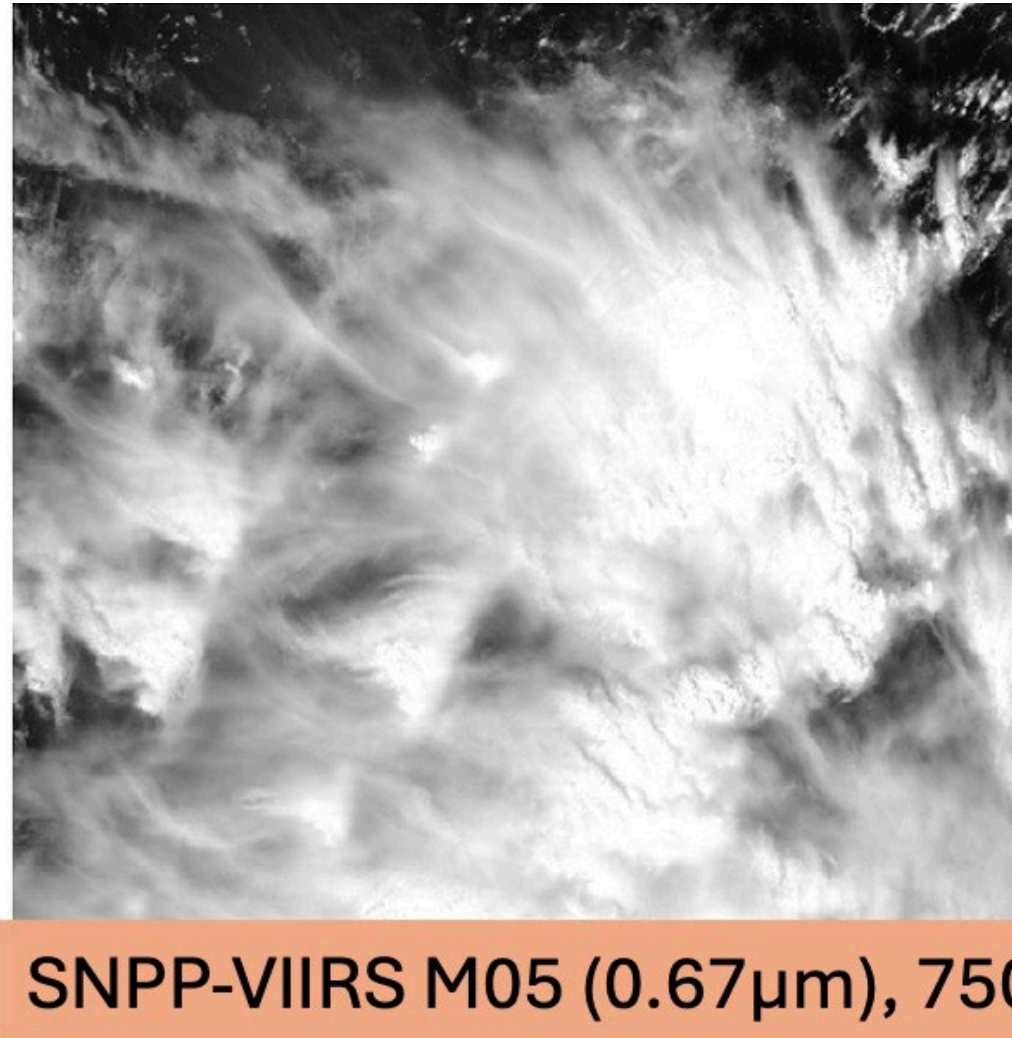
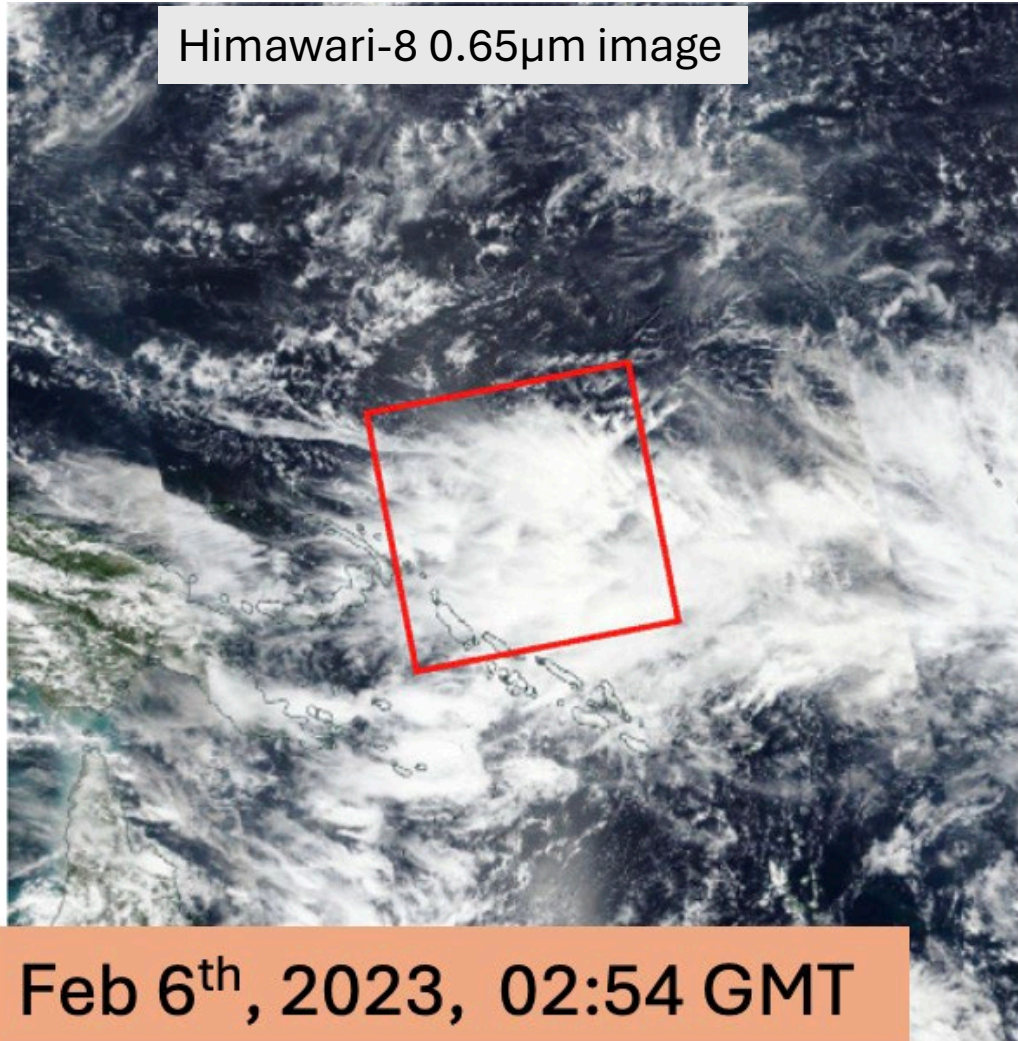
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Arun Gopalan

GSICS annual meeting, VIS/NIR session,
EUMETSAT, Darmstadt, Germany, March 14, 2024

Pixel resolution impact on DCC identification

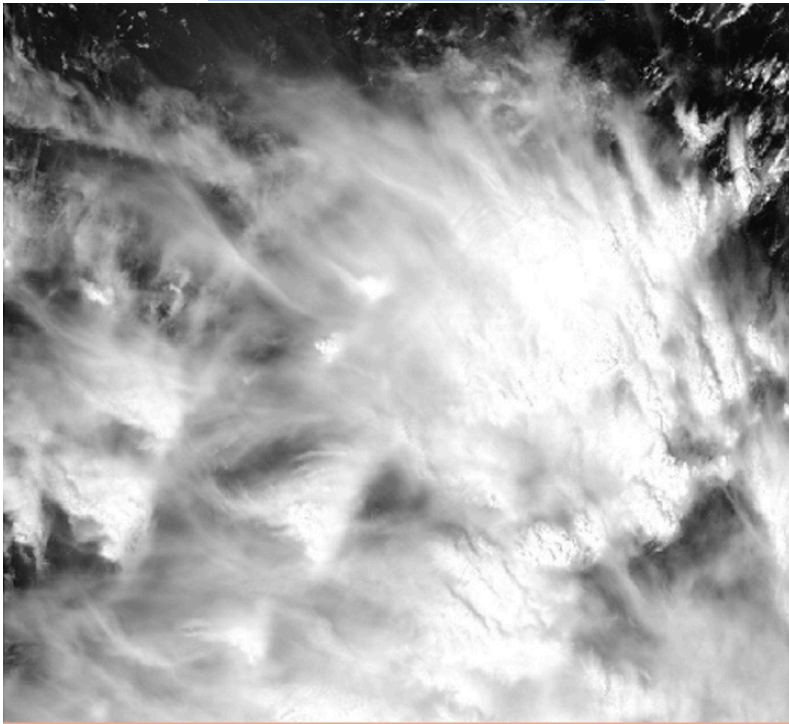
- The DCC methodology relies on identifying DCC pixels based on the following criteria:
 - $BT_{11\mu m} < 205 \text{ K}$
 - $Hom_{0.65\mu m} < 0.03$
 - $Hom_{11\mu m} < 1.0 \text{ K}$where Hom = spatial homogeneity of 3x3 pixels
- Aggregate the VIIRS M band 750-m and Landsat-8 30-m native resolution imagery to lower pixel resolutions
 - How does the pixel resolution impact the standard DCC identification thresholds?
 - Is the DCC reflectance PDF shape dependent on pixel resolution?
- Can the reference DCC reflectance be transferred to other sensors with differing pixel resolution?

SNPP VIIRS M05 DCC 750-m TSP granule East of Solomon Islands

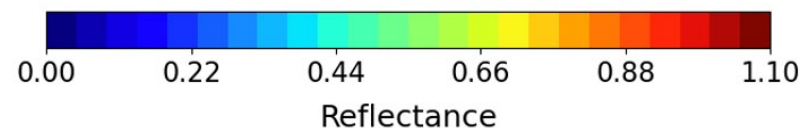
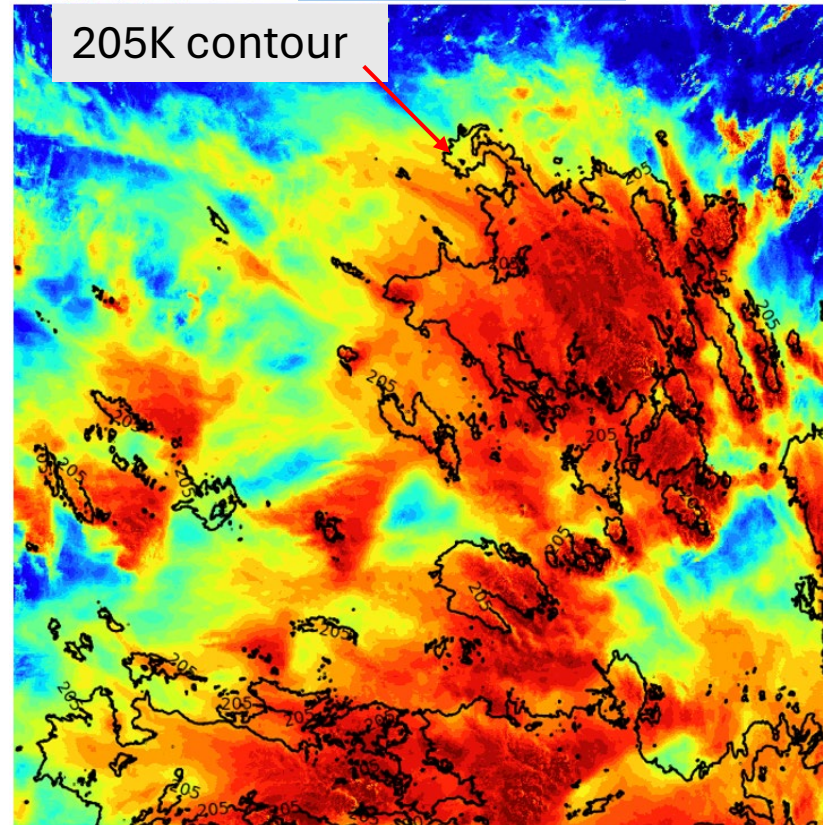


SNPP VIIRS M05 DCC 750-m granule, East of Solomon Islands

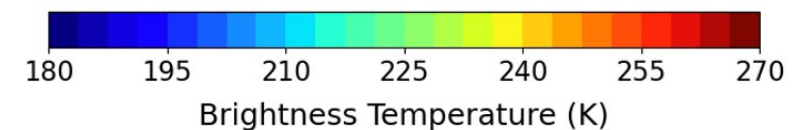
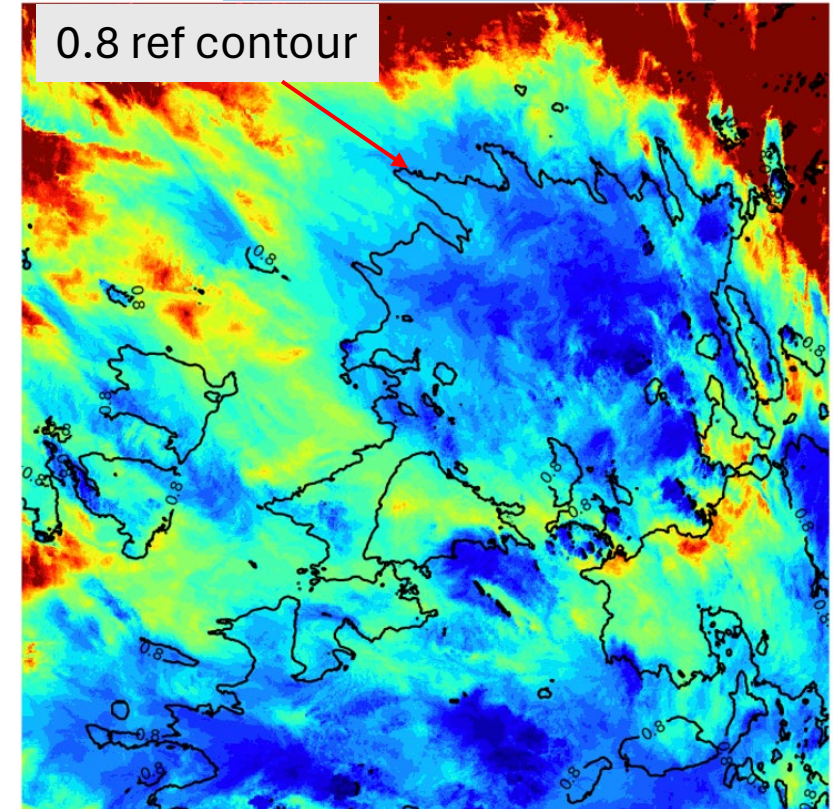
SNPP-VIIRS, 750m



M05 0.67 μ m

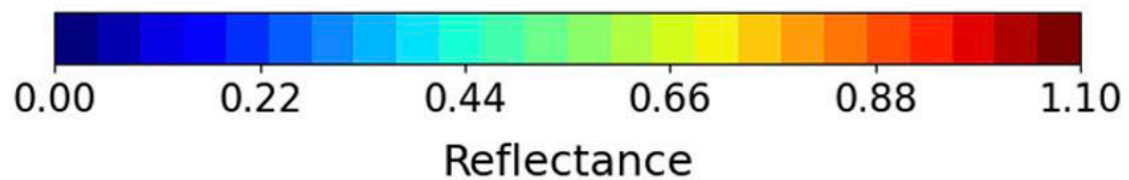
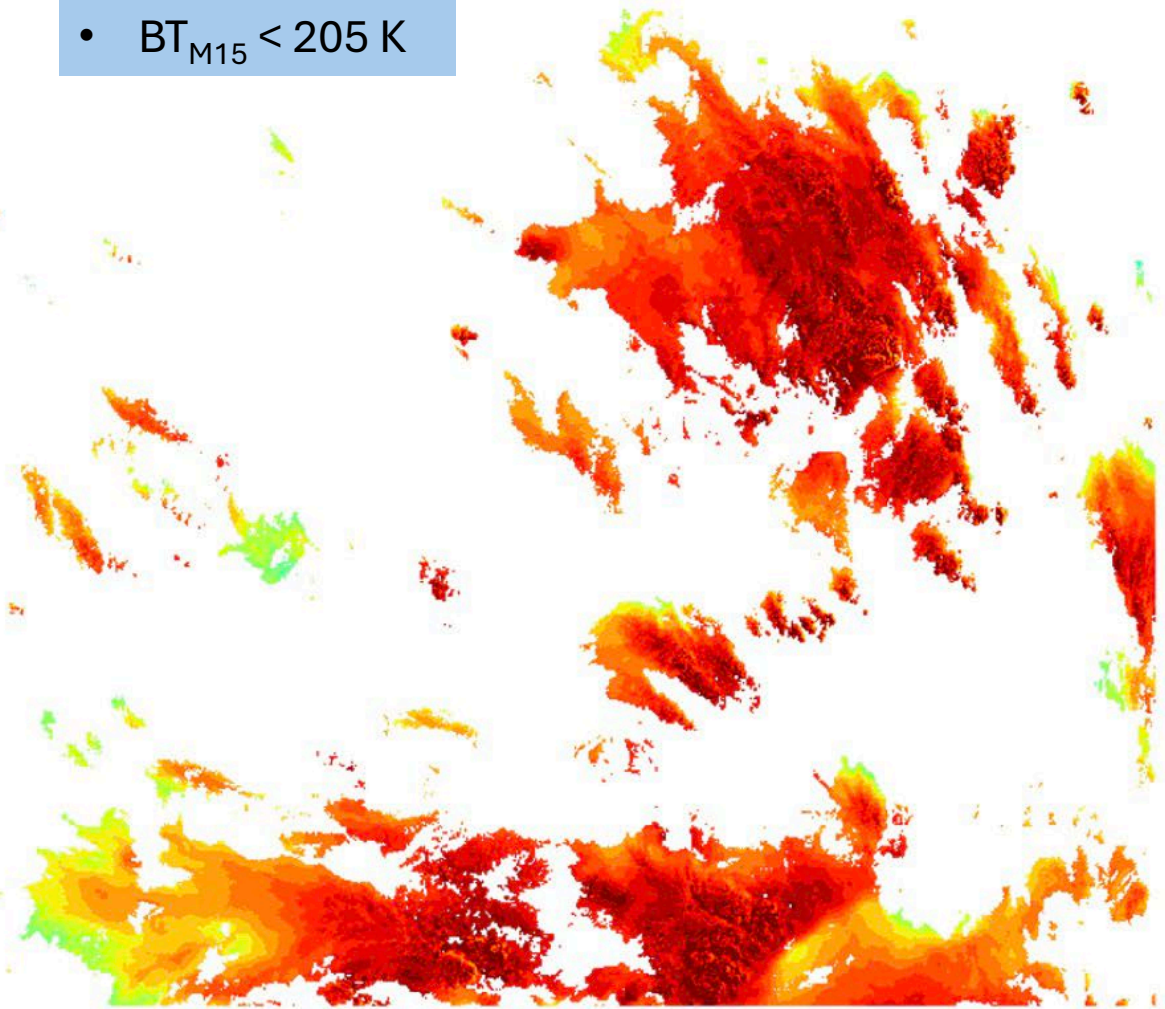


M15 11 μ m BT



M05 pixel reflectances

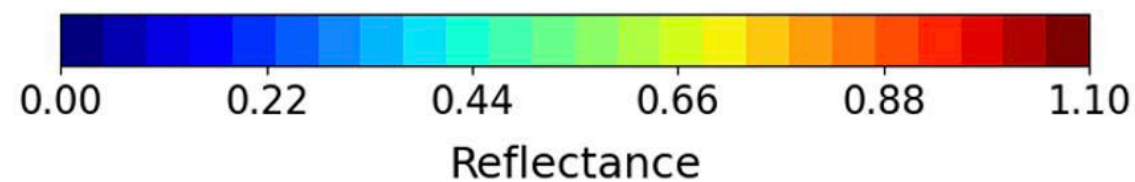
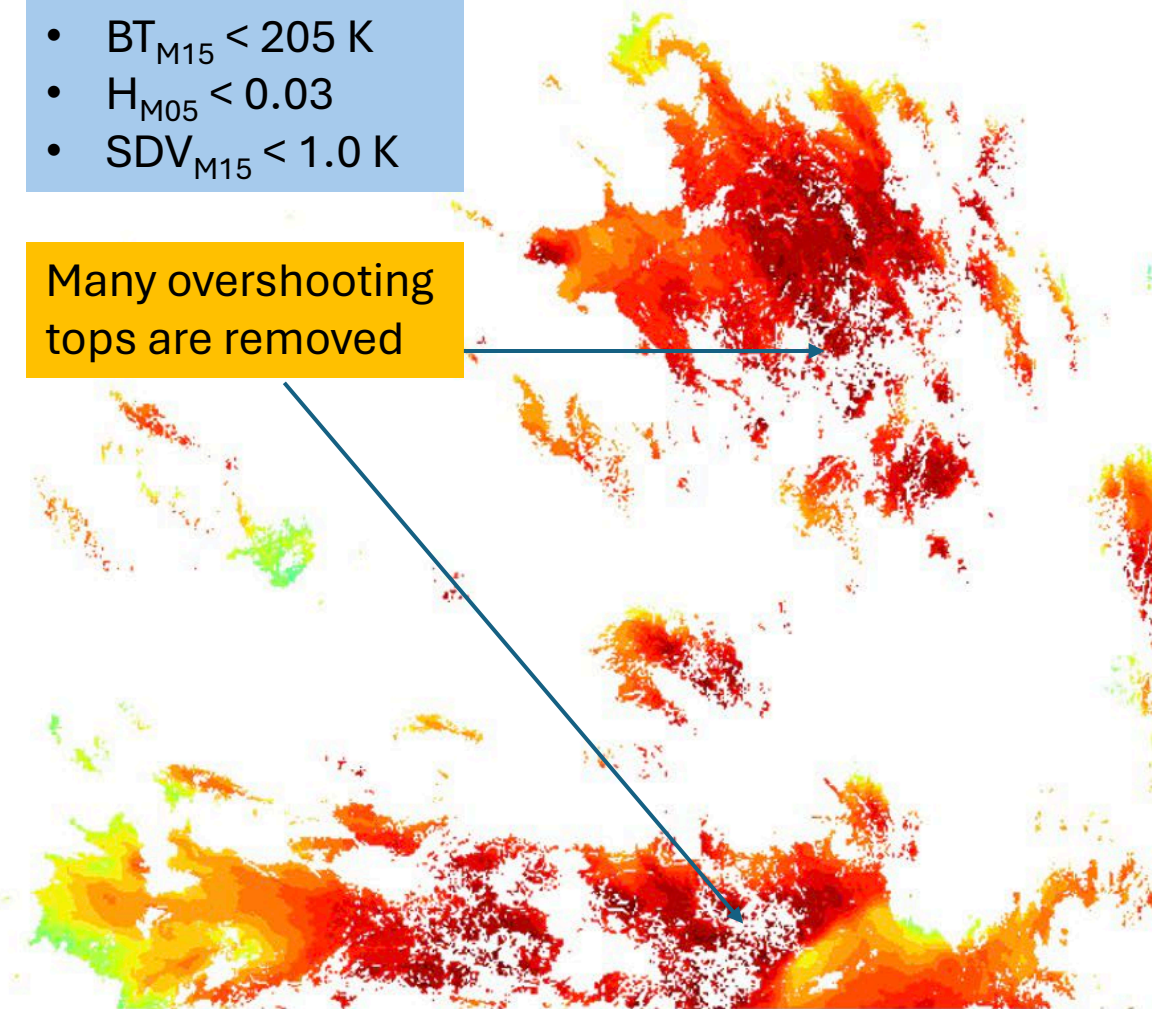
- $BT_{M15} < 205$ K



M05 pixel reflectances (w/ H_s thresholds)

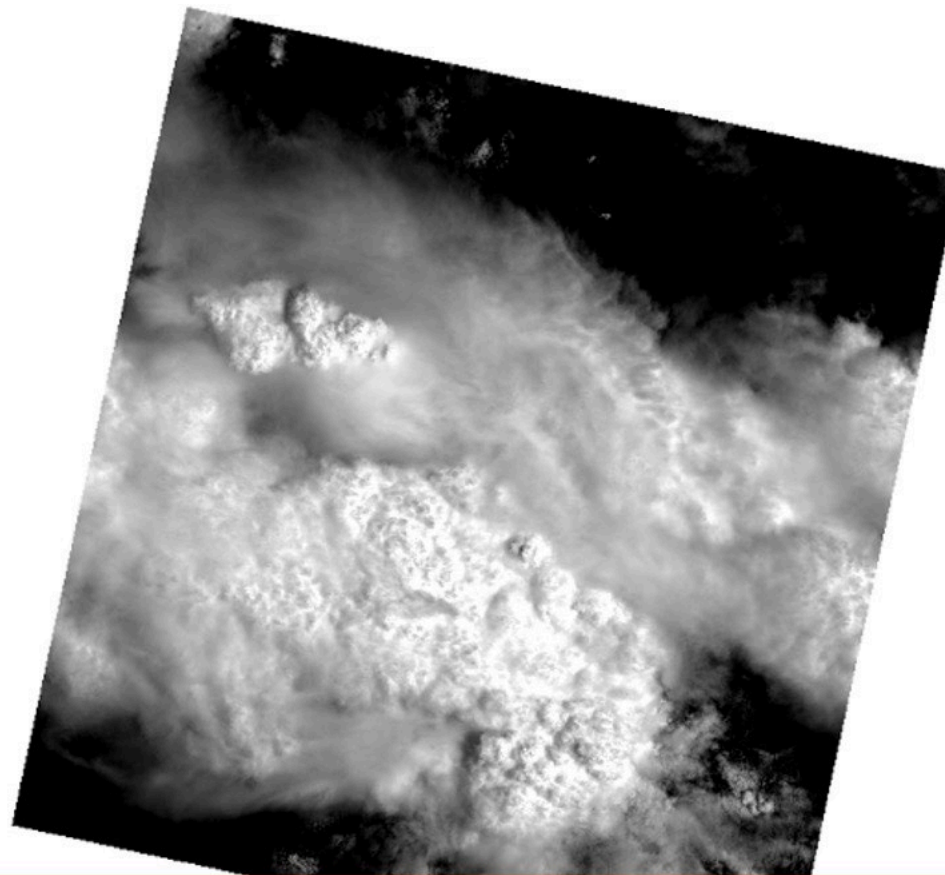
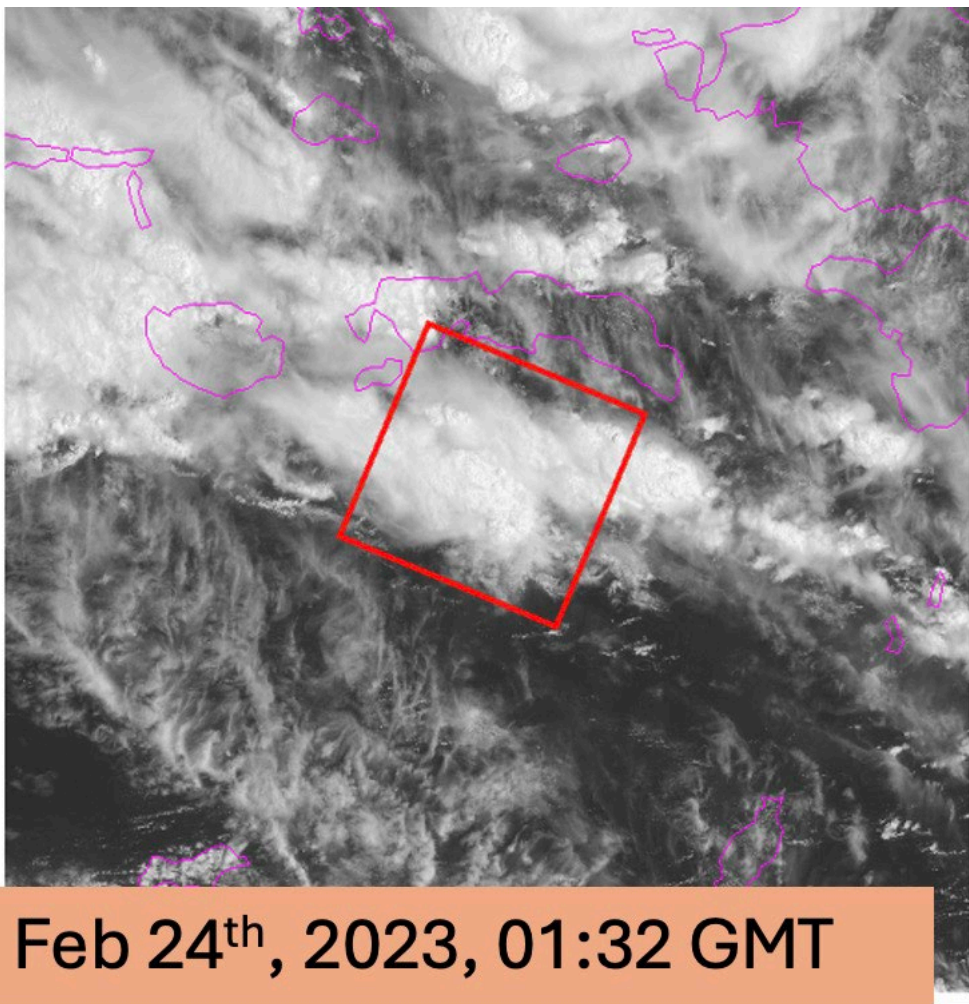
- $BT_{M15} < 205$ K
- $H_{M05} < 0.03$
- $SDV_{M15} < 1.0$ K

Many overshooting tops are removed



Landsat-8 OLI/TIRS B4 30-m TWP granule

Banda Arc, Indonesia

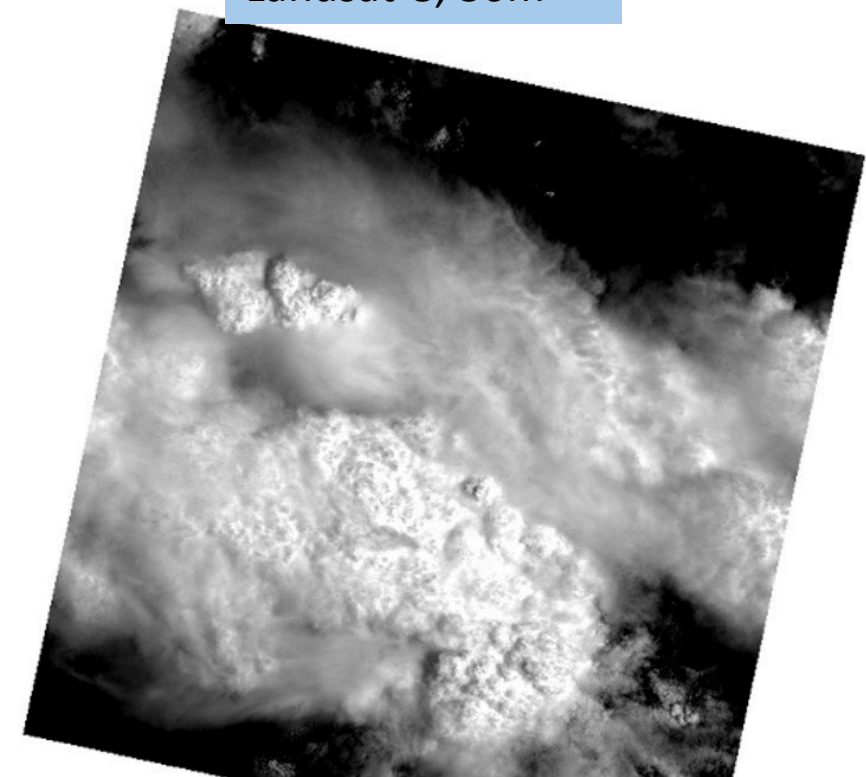


Feb 24th, 2023, 01:32 GMT

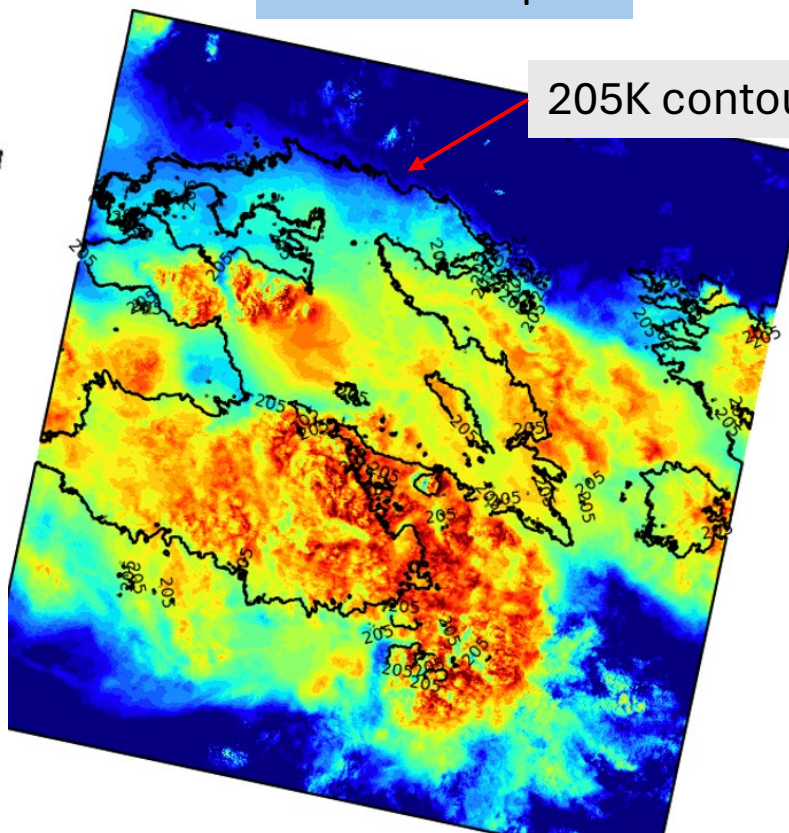
Landsat-8 OLI/TIRS B4 (0.66 μ m), 30m

Landsat-8 OLI/TIRS B4 30-m TWP granule Banda Arc, Indonesia

Landsat-8, 30m

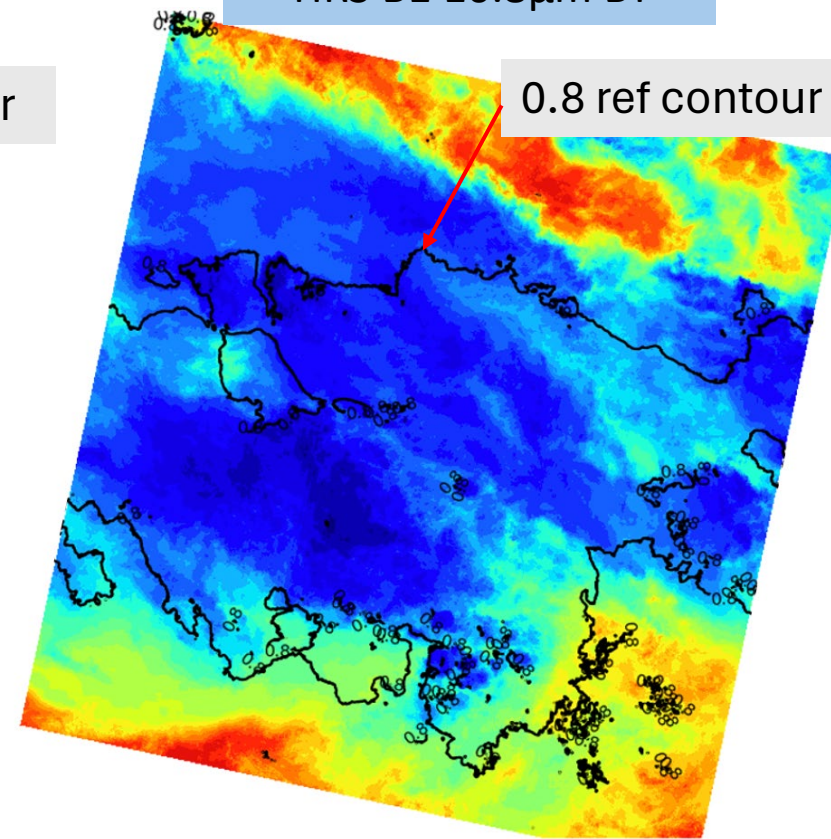


OLI B04 0.66 μ m

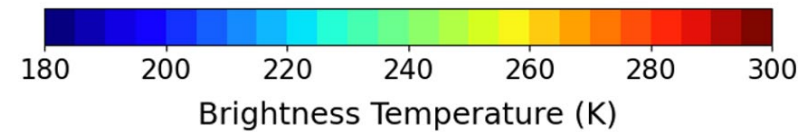
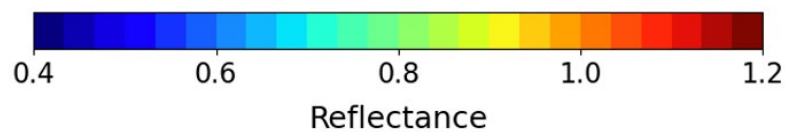


205K contour

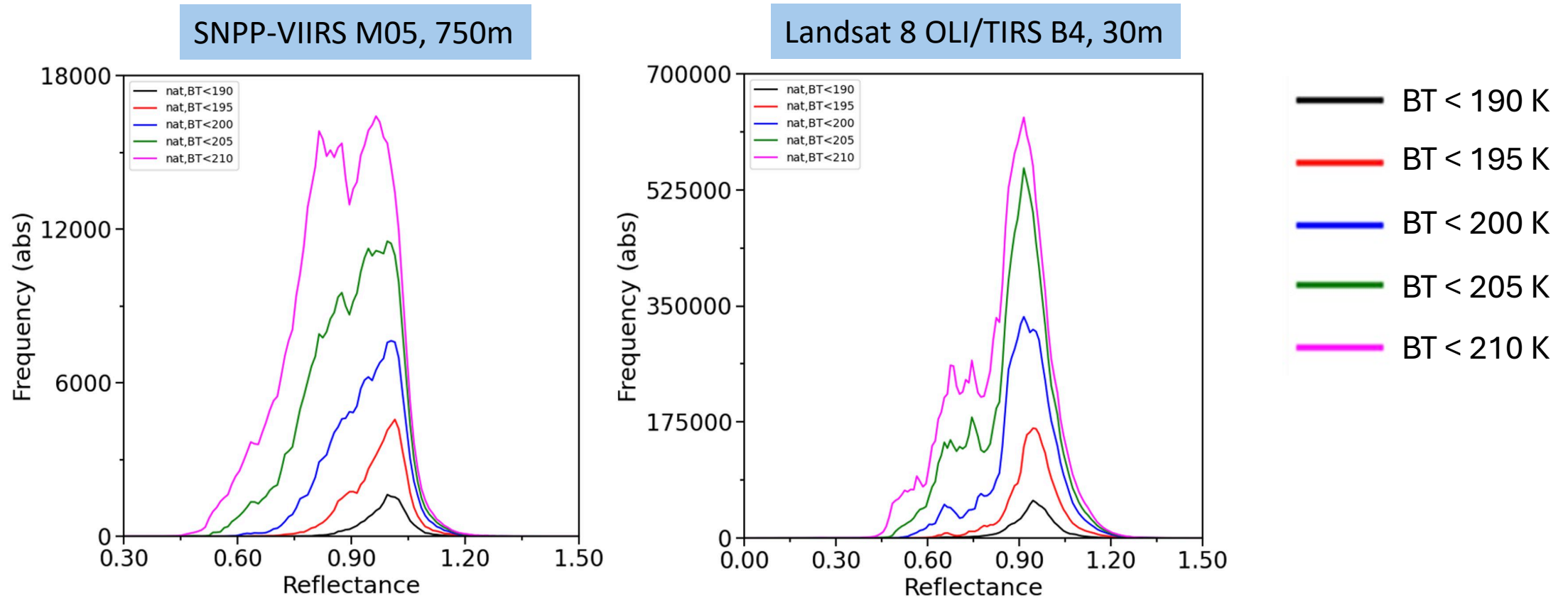
TIRS B1 10.8 μ m BT



0.8 ref contour



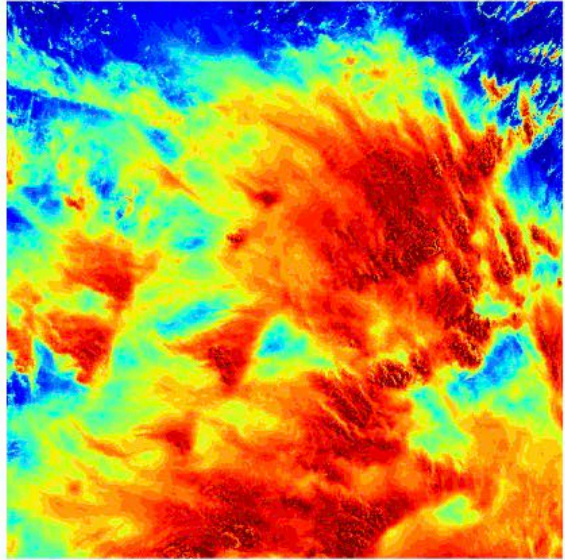
BT Threshold Sensitivity Analysis



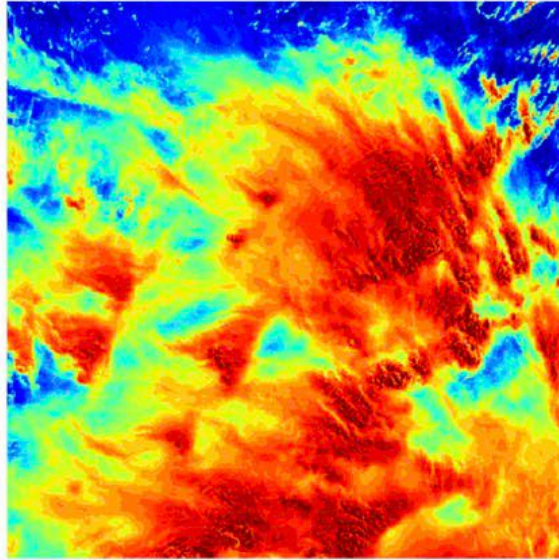
- Decreasing the BT threshold decreases the skewness or darker tail of the PDF
- Increasing the BT threshold increases the frequency of DCC identified pixels

0.65 μ m reflectance images by pixel resolution

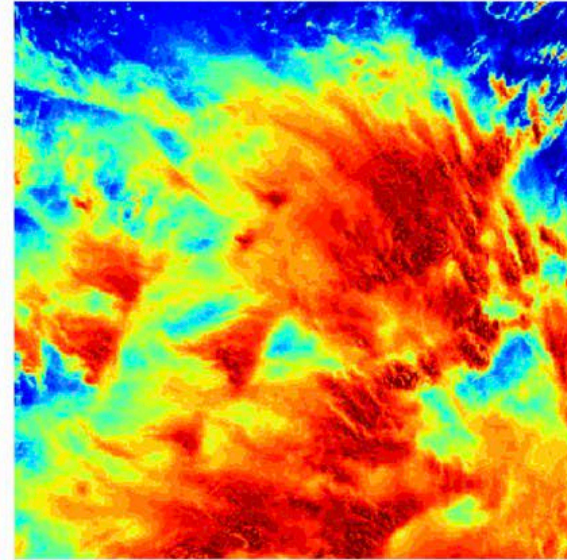
VIIRS
M05



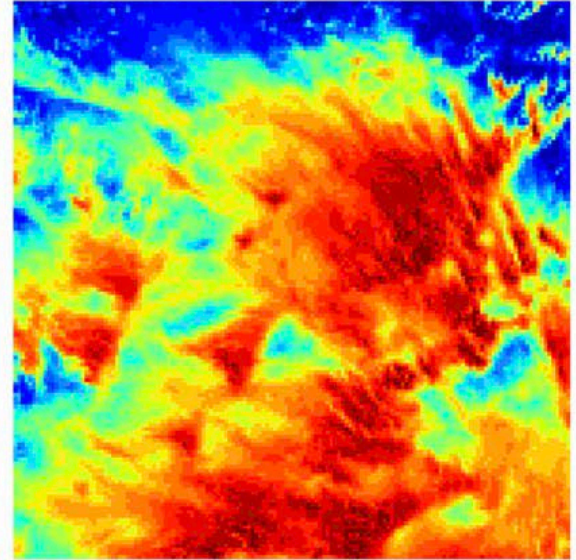
0.75 km



1.5 km

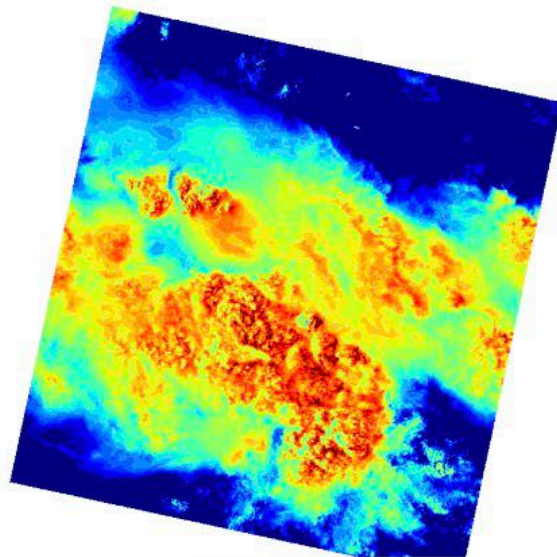


3 km

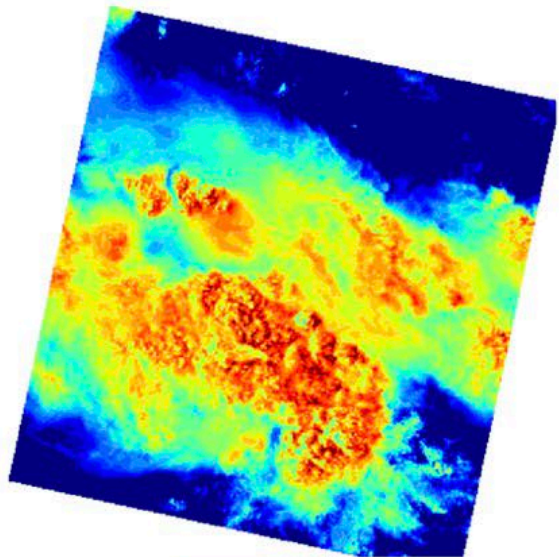


6 km

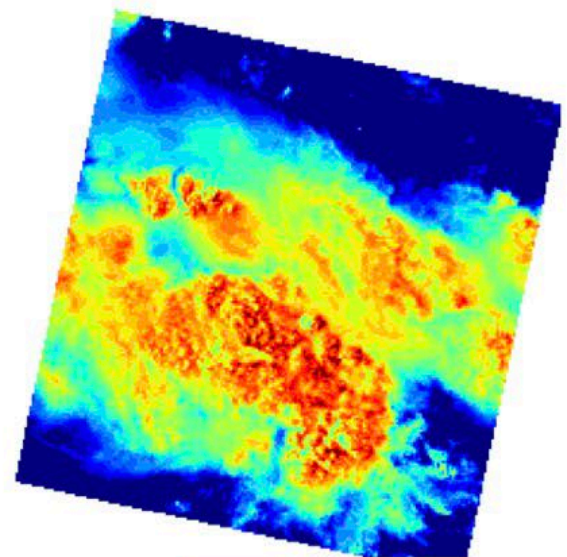
OLI B4



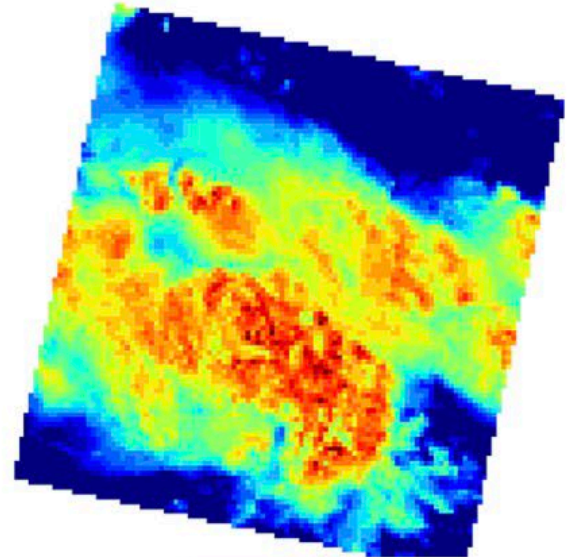
30 m



0.48 km



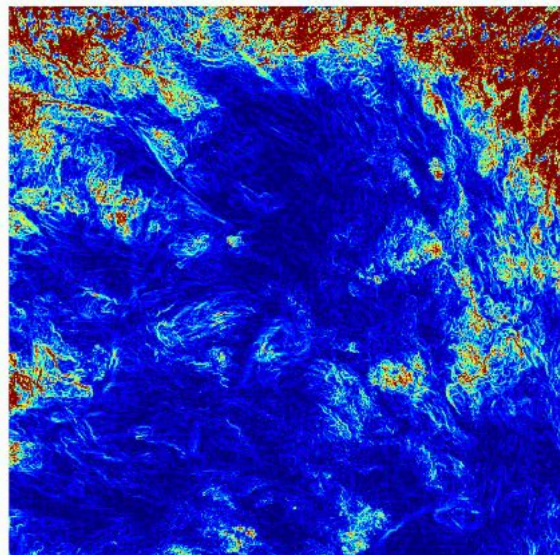
0.96 km



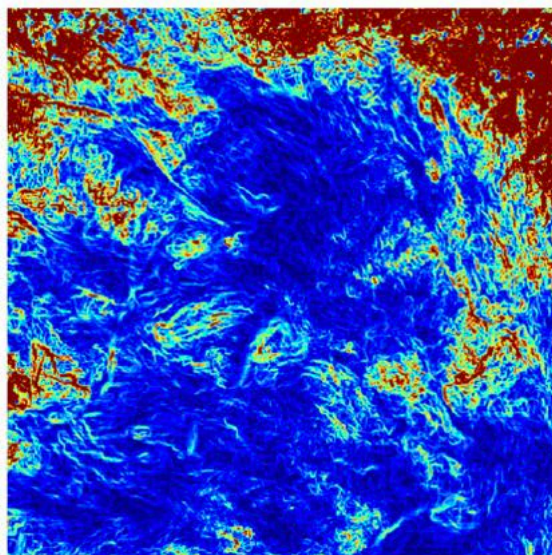
1.92 km

0.65 μ m reflectance 3x3 homogeneity images by pixel resolution

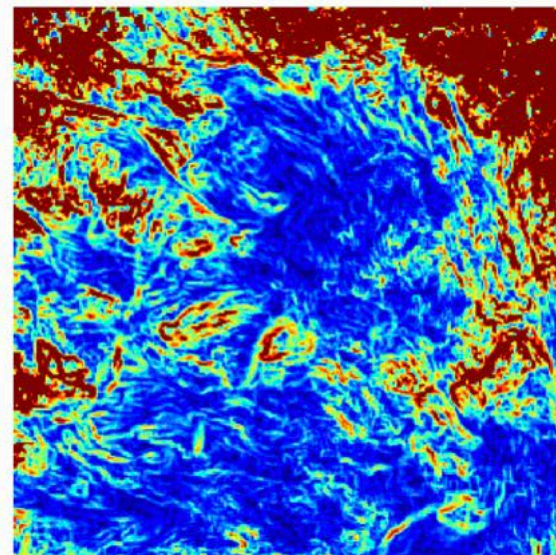
VIIRS
M05



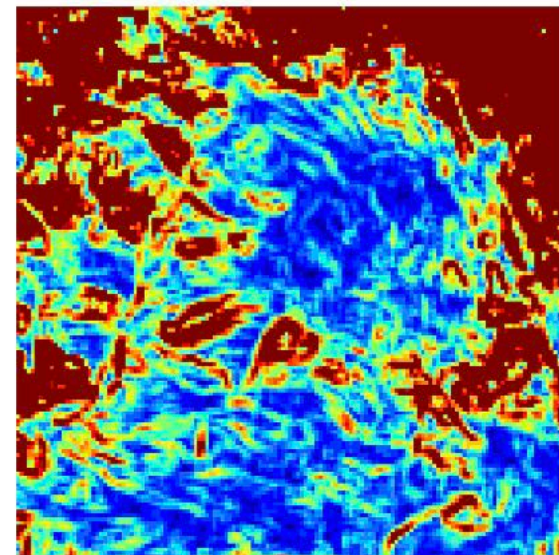
0.75 km



1.5 km

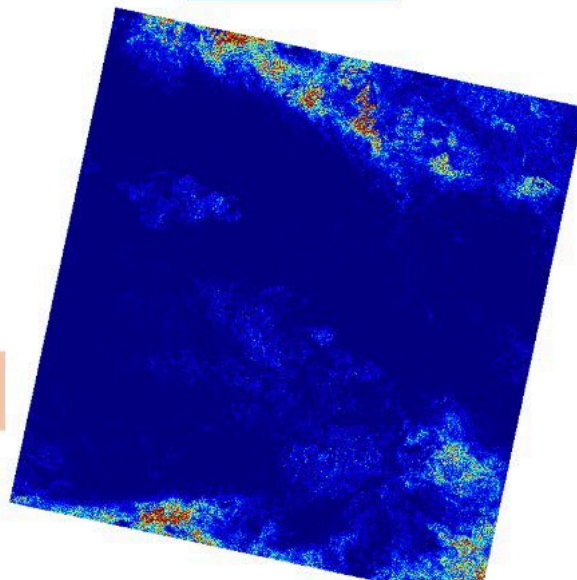


3 km

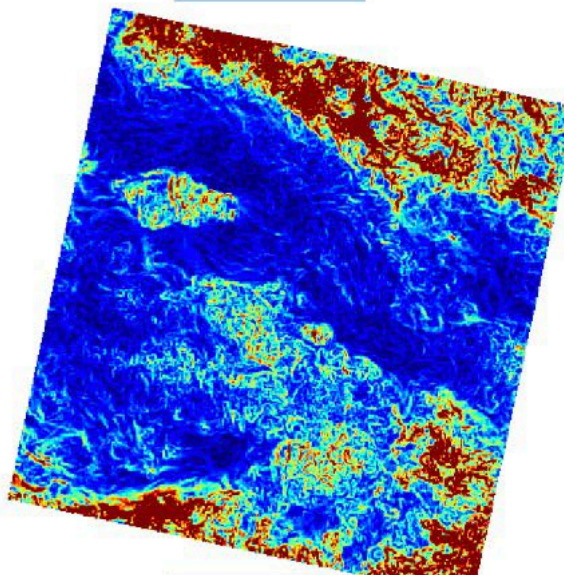


6 km

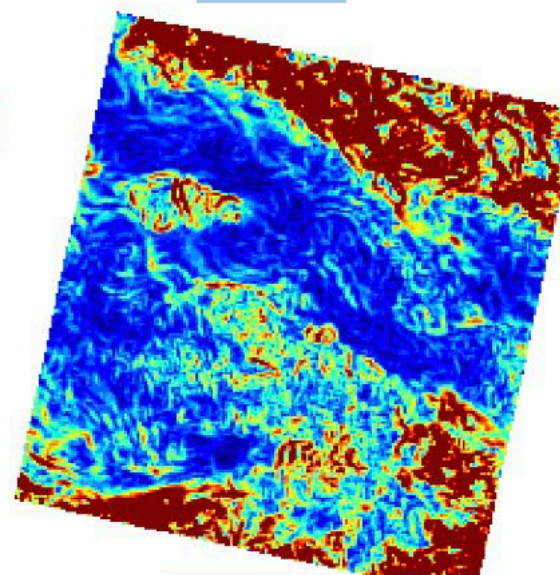
OLI B4



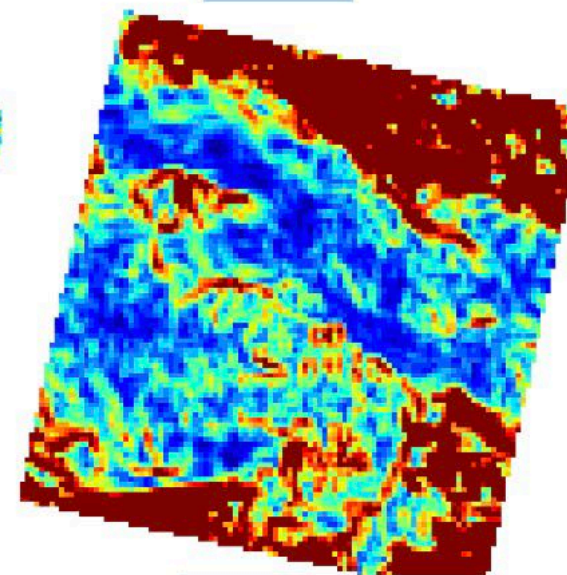
30 m



0.48 km



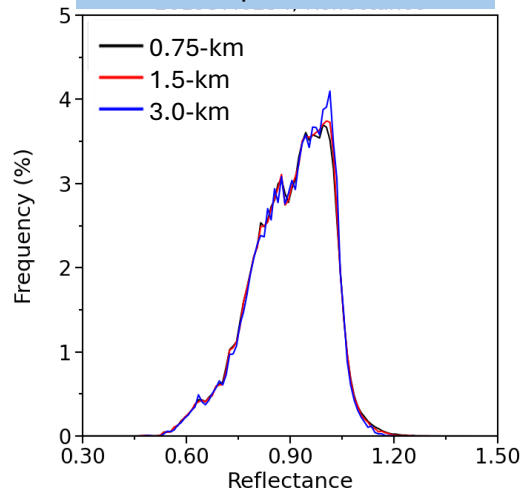
0.96 km



1.92 km

PDF statistics using homogeneity thresholds

VIIRS M05 0.65 μ m
BT_{11 μ m} < 205K



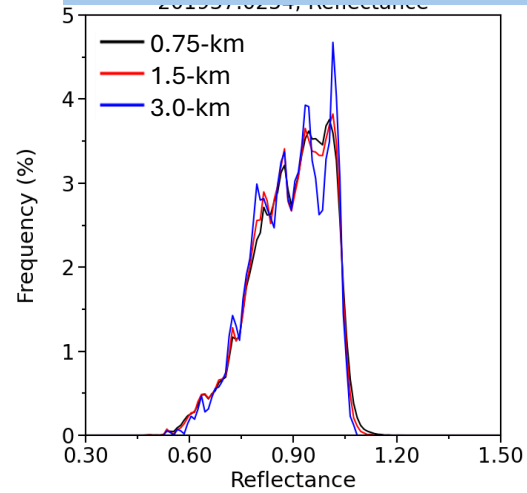
MEAN
0.900
0.901
0.902

MODE
0.995
1.005
1.015

NUM
311843
77897
19398

M15 < 205

VIIRS M05 0.65 μ m
BT_{11 μ m} < 205K, Hom on



MEAN
0.892
0.890
0.889

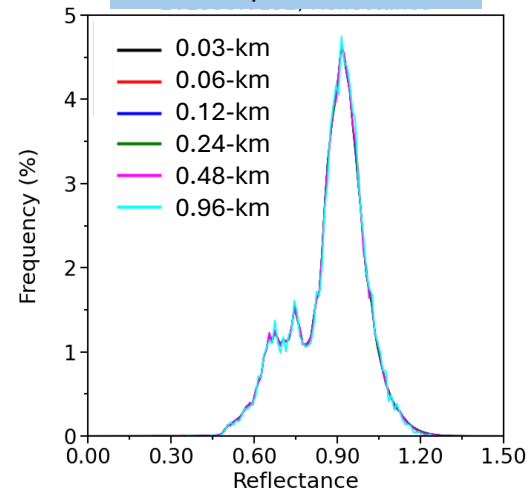
MODE
1.005
1.015
1.015

NUM
220937
40778
5754

M15 < 205
HM05 < 0.03
SDVM15 < 1.0

BT _{11μm} < 205K, Hom on	MEAN	MODE	NUM
x1 (0.75km)	0.892	1.005	220937
x2 (1.5km)	0.890	1.015	40778
x4 (3.0km)	0.889	1.015	5754

OLI B04 0.65 μ m
BT_{11 μ m} < 205K



MEAN
0.875
0.875
0.875
0.875
0.875
0.876

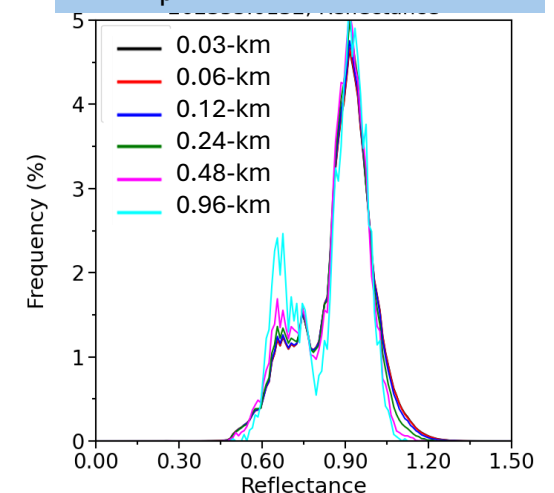
MODE
0.915
0.915
0.915
0.915
0.915
0.915

NUM
11999209
2999998
749741
187333
46779
11645

B10 < 205

BT _{11μm} < 205K, Hom on	MEAN	MODE	NUM
x1 (0.03km)	0.875	0.915	11979587
x2 (0.06km)	0.875	0.915	2967211
x4 (0.12km)	0.873	0.915	707787
x8 (0.24km)	0.867	0.915	152943
x16 (0.48km)	0.858	0.915	27817
x32 (0.96km)	0.850	0.915	3854

OLI B04 0.65 μ m
BT_{11 μ m} < 205K, Hom on



MEAN
0.875
0.875
0.873
0.867
0.858
0.850

MODE
0.915
0.915
0.915
0.915
0.915
0.915

NUM
11979587
2967211
707787
152943
27817
3854

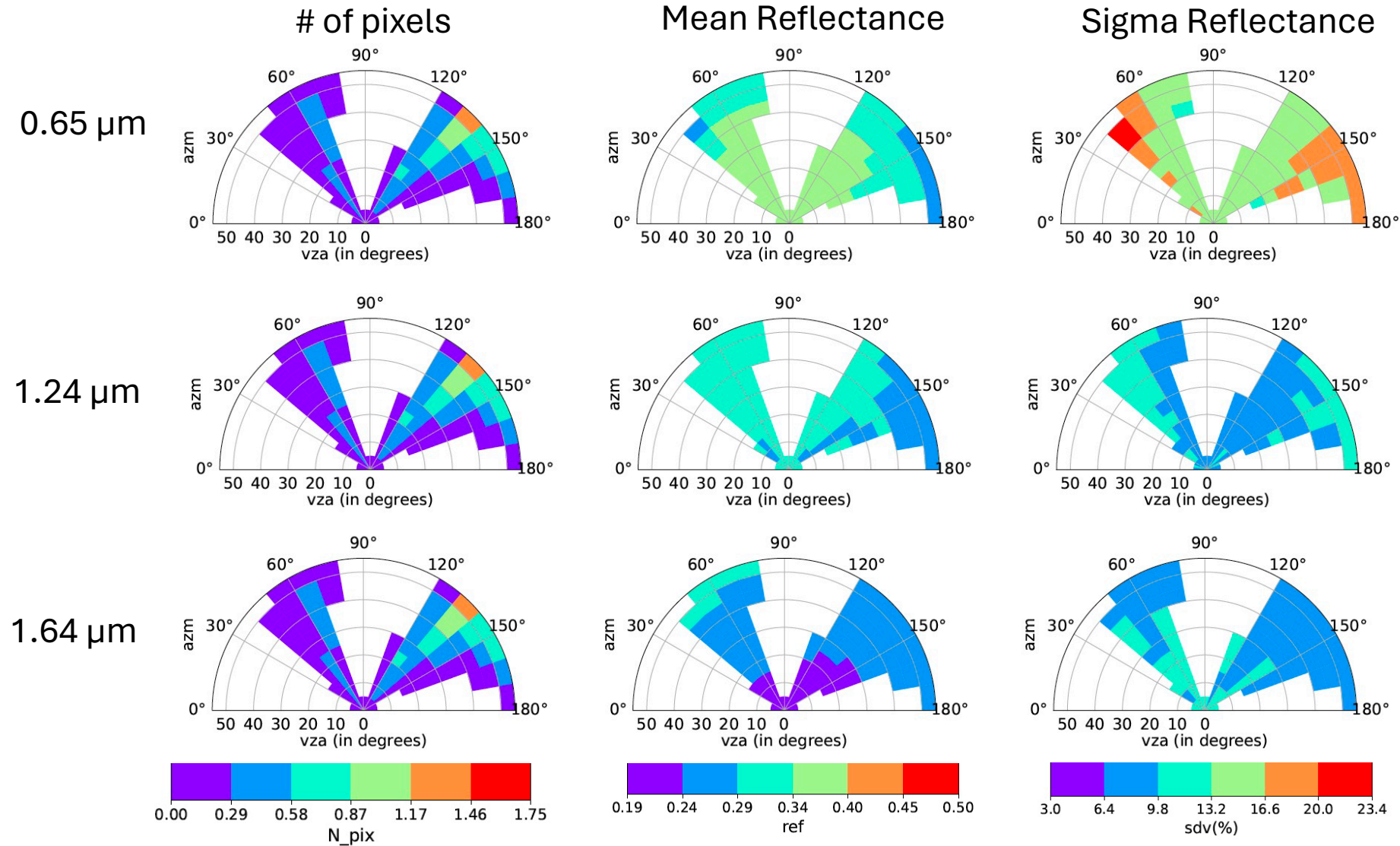
B10 < 205
HB4 < 0.03
SDVB10 < 1.0

- For these images the homogeneity thresholds or pixel resolution do not significantly change the shape of the PDF

DCC BRDF netCDF files

- For visible wavelengths the DCC reflectance is well behaved
 - Use the Hu DCC BRDF model
 - For SWIR bands the DCC reflectance is wavelength dependent
 - Need wavelength specific DCC BRDFs
- Empirical DCC reflectance BRDFs are based on angular binned pixel-level DCC identified reflectances
- Standardization of DCC BRDFs amongst agencies allows the DCC BRDFs to be shared
 - Make sure the DCC BRDF netCDF file is self describing for traceability and universal implementation

Terra-MODIS DCC BRDFs for $35^\circ < \text{SZA} < 40^\circ$



DCC BRDF netCDF parameters

netcdf file:/Users/ddoellin/Desktop/DCC_BRDF_2023/DCC_TERRA_MODIS_ADM_All_Months_TWP.nc { dimensions:

```
n_channel = 4;  
n_sza = 18;  
n_month = 13;  
n_raa = 18;  
n_vza = 11;
```

```
group: geometry { variables: float nbin_sza_bound(n_sza=18); :long_name = "solar zenith angle bin boundaries"; :units = "degrees"; :lo_bound = 0.0, 5.0, 10.0, 15.0,  
20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55.0, 60.0, 65.0, 70.0, 75.0, 80.0, 85.0; // double :high_bound = 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55.0, 60.0,  
65.0, 70.0, 75.0, 80.0, 85.0, 90.0; //
```

```
double float nbin_raa_bound(n_raa=18); :long_name = "relative azimuth angle bin boundaries"; :units = "degrees"; :lo_bound = 0.0, 10.0, 20.0, 30.0, 40.0, 50.0, 60.0,  
70.0, 80.0, 90.0, 100.0, 110.0, 120.0, 130.0, 140.0, 150.0, 160.0, 170.0; // double :high_bound = 10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0, 110.0, 120.0,  
130.0, 140.0, 150.0, 160.0, 170.0, 180.0; //
```

```
double float nbin_vza_bound(n_vza=11); :long_name = "view zenith angle bin boundaries"; :units = "degrees"; :lo_bound = 0.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0,  
40.0, 45.0, 50.0, 55.0, 60.0, 65.0, 70.0, 75.0, 80.0, 85.0; // double :high_bound = 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55.0, 60.0, 65.0, 70.0, 75.0, 80.0,  
85.0, 90.0; //
```

```
double float raa_bin_centers(n_raa=18); :centers = 5.0, 15.0, 25.0, 35.0, 45.0, 55.0, 65.0, 75.0, 85.0, 95.0, 105.0, 115.0, 125.0, 135.0, 145.0, 155.0, 165.0, 175.0; //  
double :long_name = "relative azimuth angle bin centers"; :units = "degrees"; :valid_range = 0.0f, 180.0f; // float :bounds = "raa_bound"; float
```

```
vza_bin_centers(n_vza=11); :centers = 2.5, 7.5, 12.5, 17.5, 22.5, 27.5, 32.5, 37.5, 42.5, 47.5, 52.5; //  
double :long_name = "view zenith angle bin centers"; :units = "degrees"; :valid_range = 0.0f, 90.0f; // float :bounds = "vza_bound";
```

```
float sza_bin_centers(n_sza=18); :long_name = "solar zenith angle bin centers"; :units = "degrees"; :valid_range = 0.0f, 90.0f; //  
float :bounds = "sza_bound"; :centers = 2.5, 7.5, 12.5, 17.5, 22.5, 27.5, 32.5, 37.5, 42.5, 47.5, 52.5, 57.5, 62.5, 67.5, 72.5, 77.5, 82.5, 87.5; // double
```

DCC BRDF netCDF parameters

```
group: channel_data { variables: String channel_id(n_channel=4);
:channel_names = "B1", "B4", "B6", "B2";
:wavelengths = "1.24um", "1.64um", "2.12um", "1.37um";
String month_id(n_month=13); :months = "January", "February", "March", "April", "May", "June", "July", "August", "September", "October",
"November", "December", "Annual";

float channel_brdf_coeff(n_sza=18, n_vza=11, n_raa=18, n_channel=4, n_month=13);
float number_of_pixels(n_sza=18, n_vza=11, n_raa=18, n_channel=4, n_month=13);
float standard_deviation(n_sza=18, n_vza=11, n_raa=18, n_channel=4, n_month=13); :unit = "%"; } //

global attributes:
:title = "DCC BRDF coefficients (TWP)";
:satellite = "TERRA";
:instrument = "MODIS"; :collection = "NASA C7 product";
:DCC_latitude_domain = "±30°";
:DCC_longitude_domain = "95° to 175°"; :DCC_time_range = "Jan 2002 to Dec 2010";
:DCC_temperature_threshold = "<210 K";
:DCC_BT_channel = "B31(11μm)";
:VZA_threshold = "<60°";
:SZ threshold = "<82°";
:IR_threshold = "<1%";
:VIS_std_threshold = "<3%";
:RAA_threshold = "0° to 180° (0° to 90° as forward scatter)";
:fill_value = -9999.0; // double :created = "2024-01-10 16:15:37";
:author = "Prathana Khakurel";
```

Conclusions

- DCC identification thresholds
 - Colder BT thresholds reduce the tail of the PDF at the expense of sampling
 - The spatial homogeneity thresholds remove the overshooting tops and corresponding shadows and partially reduce the PDF tail
- Preliminary pixel resolution results
 - Pixel resolution impacts the homogeneity factor to identify DCC pixels
 - Pixel resolution seems to have only a slight impact on DCC PDF shape allowing for the potential of DCC inter-calibration across pixel resolutions
- DCC BRDF netCDF formats
 - Make sure all netCDF files are self describing
 - Allows DCC BRDF to be shared amongst agencies